HOW TO WRITE A LAB REPORT

Science is a process in which individual scientists develop ideas and then, through the medium of scientific journal articles, seek to convince the scientific community that their ideas/theories are valid. Learning how to communicate your ideas effectively is a very important skill for a scientist (and is useful in many other professions as well).

A complete paper follows the following format:

TITLE PAGE

ABSTRACT

I. INTRODUCTION

II. THEORETICAL BACKGROUND

III. EXPERIMENTAL DESIGN AND PROCEDURE

IV. OBSERVATIONS

V. ANALYSIS

a. Method of analysis
b. Presentation of results
c. Discussion of results
d. Suggestions for future improvements

VI. CONCLUSIONS

The format provides some shortcuts for busy people. Readers like to find out in a hurry if a paper is actually of interest or importance to them. The *abstract* section provides a summary of the article and its most important results, so the reader only has to read a few sentences to determine if the entire paper is relevant to them. The *introduction* and *conclusions* contain a little more information – usually the reader goes to the introduction for more information about the purpose/method behind the experiment, and the conclusion for more detail on the results summarized in the abstract. If all of these are of interest to the reader, the reader then delves further into the paper.

Each of the above sections is discussed on the pages that follow. You are encouraged to read the entire paper before you write your first lab report in the course. Then, throughout the semester, you can refer to the individual sections as needed.

At times you will not be required to write a full, formal report. When this happens, the expectation will be that you will follow the guidelines here to write the sections of the report which you are asked to work on.

Unless explicitly stated, each student must write an independent lab report. Partners are encouraged to discuss the results of the lab activity, but each student must write their own report. Plagiarism is not acceptable and may result in a mark of zero.

Title Page

The title page should include the following information – a descriptive title, your name, the name(s) of your partner(s), the course title, and the date. An abstract should appear four lines below the date and have the heading ABSTRACT.

Abstract

The abstract must be able to stand by itself, it must be brief, and it must include the principal numerical results (if any) of the experiment. Its purpose is to help a reader to quickly decide whether or not your report is of significant interest for him/her to continue reading. If you were beginning a research project, one of the first things you would do would be to read the abstracts of recent articles that might be helpful – you only have so many hours in the day and good abstracts make it possible to determine *quickly* which articles are relevant to the work you wish to pursue. Its structure generally consists of three parts:

- ☐ What did you do
- ☐ What were your results
- ☐ What do these results tell you

A sample abstract is provided for you below. See if the abstract addresses the requirements listed above.

The relationship between air resistance and speed was studied by measuring the time of travel for coffee filters of different mass yet uniform surface area. Results show, within the limits of accuracy of the experiment, that the air resistance is a function of the square of the speed of the moving object, that is, $F \propto v^2$. This is in agreement with the results reported in literature (Smith, 1992, 374).

*** Note that when you are citing a source, you must include the author's name, year of publication and then page number. (ex. Smith, 1992, 374)

Introduction

The introduction indicates the primary thrust or purpose of the experiment without indicating the results. It does not have to stand by itself and may refer to later parts of the report such as a diagram or a graph. Such reference should be numbered.

The introduction should include:

- ☐ theory to be tested or purpose
- ☐ the quantities to be measured
- ☐ assumptions under which the experiment is to be done
- ☐ expected results or hypothesis

Again, see if the introduction below addresses the above criteria. This introduction is from a different experiment.

When objects are in motion, they exhibit either uniform motion or accelerated motion. Position-time graphs that produce a constant slope indicate that the motion is uniform. To see whether or not a falling coffee filter underwent uniform or accelerated motion, the filter was dropped from different heights and the time of fall from each height was measured. The resulting data was used to plot a position (height) vs time graph. It was assumed that the filter was released from rest for each trial and that it fell vertically downward, that is, it did not sway side to side and that the distance travelled was the same each time. It was expected that the data would indicate uniform motion as air resistance would greatly impact the object's ability to accelerate.

Theoretical Background

It is very important that the theory section be written for the particular audience for which the report is intended. We will consider, for our lab reports, the audience to be one of your classmates who had to miss this lab.

The theory section is meant to provide the reader with enough mathematical or theoretical background to understand how the experiment works, what assumptions have been made, and how the experiment is related to the physics being studied. Start with basic defining equations, and show all, non-obvious intermediate algebraic steps. Clearly identify any assumptions or approximations made. An example from another lab is provided:

Any object, undergoing free-fall motion, is falling solely under the influence of gravity. According to Newton's 2nd Law, an object falling under such conditions will accelerate (Nelson, 2000, 71). The strength of the gravitational pull on the object is equivalent to the objects weight, F_g, and this strength is determined by

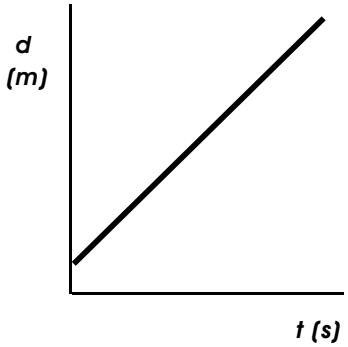
$$F_g = mg \qquad (1)$$

where 'g' is the gravitational field strength constant: 9.8 N/kg and 'm' is the object's mass, in kilograms.

Air resistance, F_{air}, is a force that acts against the direction of an object's motion. As the speed of an object increases, so does the magnitude of the air resistance it experiences. Imagine cruising at 20 km/h with your hand out the car window – you can feel the air rushing past your hand. Now imagine travelling at 80 km/h – a great deal of effort is required on your part to prevent the F_{air} from pushing your hand towards back of the car. The air resistance has become much greater.

The speed of the falling coffee filter is very low early in its flight. It thus has very little air resistance. Since the force of gravity is greater than the air resistance, the filter accelerates as per Newton's 2nd Law. However, as it picks up speed it too experiences greater air resistance.

Soon F_{air} is of the same order of magnitude as F_g; as these forces act in opposite directions they cancel each other out and the object ceases to accelerate. According to Newton's 2nd Law, the forces are balanced and thus the motion is now uniform. The speed at this moment is known as 'terminal velocity' (Smith, 1992, 452).



The larger filter has slightly more mass and thus its weight is greater (equation 1) but its larger surface area allows the air resistance to be much greater at a lower speed. This means then that the object would accelerate for a smaller period of time and thus would reach uniform motion sooner – it would have a smaller speed. Thus, in theory, the larger filter should have a smaller terminal velocity than the smaller filter as they fall.

Experimental Design and Procedure

List the materials used in the experiment. Sketch/diagram of the set-up is given enhance the ability of the reader to set-up and repeat your experiment.

Independent, dependent and controlled variables are identified.

The procedure elaborates on the part of the abstract that indicates "What did you do". The procedure is not a step by step series of instructions. It summarizes what was done yet provides enough information so that the experiment may be repeated by others. It is written in past tense and passive voice. A sample procedure follows:

A ruler was placed, vertically, along a wall and the height from which the filters were to be dropped was measured. The time for each filter to fall from this position to the floor was measured using a stopwatch. Several trials were repeated from the same drop height and the average time of fall was determined. The process was repeated for different drop heights.

Examples of some common errors made by students in writing their procedure or in communicating information in other parts of the report are outlined below:

Example 1:
INCORRECT: I added 50 mL of acid to the base in a 250 mL flask.
This sentence does not use the passive voice
CORRECT: Fifty millilitres of acid was added to the base in a 250 mL flask.
This sentence uses the passive voice; also, note that the sentence does not start with the arabic number 50.

Example 2:
INCORRECT: Next, cover the flask with a piece of foil.
CORRECT: The flask was covered with a piece of foil... *avoid using next, or then...*

Example 3:
INCORRECT: The three lenses were obtained and the light was shone through them.
CORRECT: Light was directed through each of individual lens... *you don't have to tell me that you obtained the lenses*

Example 4:
INCORRECT: The procedure tried to demonstrate the properties of...
CORRECT: The purpose of the procedure was to demonstrate the properties of... *Since when can a procedure itself try to do something?*

Example 5:
INCORRECT: The results prove that...
CORRECT: The results suggest... The results show that... *Science cannot prove but only support or suggest*

Observations

This section of the report includes any data which you measured and/or observed. No inferences appear here. Tables and graphs have numbers given to them although the graphs appear in the analysis section. Aside from the calculation of the averages of the trials, no other calculated data should appear here. Calculated data should be placed in a data table in the analysis section of the lab.

Table 1 Fall times as a function of height for various coffee filters

Height (inches)	Small Filter Time Trials (s)						Mean Time (s)		Large Filter Time Trials (s)						Mean Time (s)
64	1.53	1.43	1.30	1.37	1.39	-	1.40		2.10	2.22	1.96	2.14	-	-	2.10
59	1.20	1.53	1.40	1.30	1.40	1.31	1.36		1.84	1.84	1.89	-	-	-	1.85
46	1.25	1.13	1.08	1.06	1.05	0.95	1.09		1.50	1.51	1.65	1.70	1.53	-	1.58
40	0.86	0.98	0.91	0.92	0.97	-	0.93		1.53	1.34	1.45	1.47	1.46	-	1.45
32	0.92	0.81	0.82	0.88	0.92	-	0.87		1.31	1.26	1.23	1.34	1.16	1.16	1.24
26	0.92	0.93	0.70	0.76	0.78	-	0.82		1.11	1.16	1.09	1.16	1.07	-	1.12

A correctly prepared table should:
A. Be numbered
B. Have a descriptive title
C. Have rows and columns clearly labelled
D. Have appropriate units in the column or row headers

A correctly prepared graph should:
A. Be numbered (ex. Fig. 1)
B. Have a descriptive title
C. Have clearly labelled axes with an appropriate scale
D. Have data points that are clearly marked
E. Have a straight or curved line of best fit.

Analysis

This section is one of the most important. Data analysis is where you discuss the meaning behind your data at length. What does the data tell you? What do the graphs indicate? What do your observations suggest? It is in this section when you revisit the objective of the investigation and determine in what ways your data answers your purpose/hypothesis. You must refer to data specifically and create an argument, which supports or disproves your hypothesis. However, don't be caught saying something that your data does not support! There is nothing wrong in having an incorrect hypothesis! Simply communicate what the data is telling you.

Questions are given to you to help you formulate or expand on your analysis. Do not simply answer the questions. Integrate them as part of your analysis, making the ideas flow from one topic to another. Here is a sample analysis:

A plot of the number of coffee filters (N) versus speed (Figure 1) shows that there exists an exponential relationship between the two variables.

Further data analysis (Table 2, Figure 2) shows that the drag force (expressed as the number of coffee filters) is directly proportional to the square of the terminal speed of the falling filters. That is, $N \propto v^2$. The slope of the line is known as the drag coefficient. The resulting relationship is $N=0.78v^2$.

Error analysis follows:

The lines of best fit do not intersect the origin. This may be attributed to experimental error. It is possible that the filter was not released from the exact position (height) measured and it is also possible, that on release, the filter was given either an upward or downward initial velocity. Reaction times in starting the stopwatch at the moment of release as well as stopping the stopwatch at the moment of impact may too have attributed to this error.

Based on the above analysis you should be able to see that an analysis should:

F. briefly discuss the data
G. discuss graphs
H. discuss consistency or lack thereof with any theoretical predictions
I. shows how you calculated any numerical values (obvious ones excluded)
J. discusses the results and their implications
K. discusses potential sources of error

Conclusion

Briefly summarize everything! In a sentence or two, state whether the hypothesis is supported by the results or not. Report what you have learned.

Bibliography

Use the APA style found in "On Your Own" to indicate the sources cited/consulted.